Amendments to the Claims

Please amend Claim(s) 1, 6, 11, 16, 21, 46, 49, 50. The Claim Listing below will replace all prior versions of the claims in the application:

Claim Listing

1. (Currently Amended) A method for calibrating a camera comprising the steps of:

digitizing an image of a blank textureless surface having a uniform illumination;

from the digitized image, determining a pixel intensity drop off caused by a combination of a vignetting effect and an off-axis pixel projection effect due to camera defects; ~~and~~

from the determined pixel intensity drop off, approximating the vignetting effect and the off-axis pixel projection effect using a modeling equation; and

recovering an intrinsic parameter of the camera other than pixel intensity drop off using substantially only the determined pixel intensity drop off.

2-3. Canceled.

4. (Previously Presented) The method as claimed in Claim 1 wherein the step of determining is dependent on a camera tilt effect.

5. (Previously Presented) The method as claimed in Claim 1 further comprising the step of computing the parameters of a model by minimizing the difference between the digitized image and the model.

6. (Currently Amended) A computer program product for calibrating a camera, the computer program product comprising a computer usable medium having computer readable code thereon, including program code which:

retrieves a digitized image of a blank textureless surface having a uniform illumination;

from the digitized image, determines a pixel intensity drop off caused by a combination of a vignetting effect and an off-axis pixel projection effect; ~~and~~

from the determined pixel intensity drop off, approximating the vignetting effect and the off-axis pixel projection effect using a modeling equation; and

recovers an intrinsic parameter of the camera other than pixel intensity drop off based on substantially only the determined drop off.

7-8. Canceled.

9. (Previously Presented) The computer program product as claimed in claim 6 wherein the program code computes parameters based on a camera tilt effect.

10. (Previously Presented) The computer program product as claimed in claim 6 wherein the program code computes parameters of a model by minimizing difference between the digitized image and the model.

11. (Currently Amended) A computer system comprising:

a memory system;

an I/O system connected to the memory system;

a storage device connected to the I/O system; and

a calibration routine located in the memory system responsive to a request for calibrating a camera which:

retrieves a digitized image of a blank textureless surface having a uniform illumination;

from the digitized image, determines a pixel intensity drop off caused by a combination of a vignetting effect and an off-axis pixel projection effect; ~~and~~

from the determined pixel intensity drop off, approximating the vignetting effect and the off-axis pixel projection effect using a modeling equation; and

recovers an intrinsic parameter of the camera other than pixel intensity drop off based on substantially only the determined drop off.

12-13. Canceled.

14. (Previously Presented) The computer system as claimed in claim 11 wherein the calibration routine determines parameters dependent on a camera tilt effect.

15. (Previously Presented) The computer system as claimed in claim 11 wherein the calibration routine computes parameters of a model stored in the storage device, by minimizing difference between the digitized image and the model.

16. (Currently Amended) An apparatus for calibrating a camera comprising:

means for digitizing an image of a blank textureless surface having a uniform illumination;

means for determining a pixel intensity drop off in the digitized image caused by a combination of a vignetting effect and an off-axis pixel projection effect; ~~and~~

means for approximating the vignetting effect and the off-axis pixel projection effect in the digitized image using a modeling equation; and

means for recovering an intrinsic parameter of the camera other than pixel intensity drop off using substantially only the determined pixel intensity drop off.

17-18. Canceled.

19. (Previously Presented) The apparatus as claimed in claim 16 wherein the means for computing computes parameters based on a camera tilt effect.

20. (Previously Presented) The apparatus as claimed in claim 16 wherein the means for computing further comprises means for computing parameters of a model by minimizing difference between the digitized image and the model.

21. (Currently Amended) An apparatus for calibrating a camera comprising:

a retrieval routine which retrieves a digitized image of a blank textureless surface having a uniform illumination;

a routine which determines a pixel intensity drop off in the digitized image caused by a combination of a vignetting effect and an off-axis pixel projection effect; ~~and~~

an approximating routine which approximates the vignetting effect and the off-axis pixel projection effect in a digitized image using a modeling equation; and

a parameter computing routine which recovers an intrinsic parameter of the camera other than the pixel intensity drop off using substantially only the determined pixel intensity drop off.

22-24. Canceled.

25. (Previously Presented) The apparatus as claimed in claim 21 wherein the parameter computing routine further comprises a model routine which computes parameters of a model by minimizing difference between the digitized image and the model.

26. (Previously Presented) The method as claimed in Claim 1 wherein the intrinsic parameter is selected from the group consisting of focal length, principal point, skew and aspect ratio.

27. (Previously Presented) The method as claimed in Claim 1 wherein the intrinsic parameter is focal length.

28. (Previously Presented) The method as claimed in Claim 1 wherein the intrinsic parameter is principal point.

29. (Previously Presented) The method as claimed in Claim 1 wherein the intrinsic parameter is skew.

30. (Previously Presented) The method as claimed in Claim 1 wherein the intrinsic parameter is aspect ratio.

31. (Previously Presented) The computer program product as claimed in Claim 6 wherein the intrinsic parameter is selected from the group consisting of focal length, principal point, skew and aspect ratio.

32. (Previously Presented) The computer program product as claimed in Claim 6 wherein the intrinsic parameter is focal length.

33. (Previously Presented) The computer program product as claimed in Claim 6 wherein the intrinsic parameter is principal point.

34. (Previously Presented) The computer program product as claimed in Claim 6 wherein the intrinsic parameter is skew.

35. (Previously Presented) The computer program product as claimed in Claim 6 wherein the intrinsic parameter is aspect ratio.

36. (Previously Presented) The computer system as claimed in Claim 11 wherein the intrinsic parameter is selected from the group consisting of focal length, principal point, skew and aspect ratio.

37. (Previously Presented) The computer system as claimed in Claim 11 wherein the intrinsic parameter is focal length.

38. (Previously Presented) The computer system as claimed in Claim 11 wherein the intrinsic parameter is principal point.

39. (Previously Presented) The computer system as claimed in Claim 11 wherein the intrinsic parameter is skew.

40. (Previously Presented) The computer system as claimed in Claim 11 wherein the intrinsic parameter is aspect ratio.

41. (Previously Presented) The apparatus as claimed in Claim 16 wherein the intrinsic parameter is selected from the group consisting of focal length, principal point, skew and aspect ratio.

42. (Previously Presented) The apparatus as claimed in Claim 16 wherein the intrinsic parameter is focal length.

43. (Previously Presented) The apparatus as claimed in Claim 16 wherein the intrinsic parameter is principal point.

44. (Previously Presented) The apparatus as claimed in Claim 16 wherein the intrinsic parameter is skew.

45. (Previously Presented) The apparatus as claimed in Claim 16 wherein the intrinsic parameter is aspect ratio.

46. (Currently Amended) A method for calibrating a camera comprising the steps of:

digitizing an image of a blank textureless surface having a uniform illumination;

from the digitized image, determining a pixel intensity drop off caused by a combination of a vignetting effect and an off-axis pixel projection effect; ~~and~~

from the determined pixel intensity drop off, approximating the vignetting effect and the off-axis pixel projection effect using a modeling equation; and

recovering focal length of the camera using substantially only the determined pixel intensity drop off.

47. (Previously Presented) The method of claim 46 wherein the off-axis pixel projection effect is dependent on the focal length of the camera.

48. (Previously Presented) The method of claim 47 wherein illuminance of an off-axis image point in the digitized image is proportional to the focal length and distance of the point from the center of the digitized image on the optical axis.

49. (Currently Amended) A method for calibrating a camera comprising the steps of:

digitizing an image of a blank textureless surface having a uniform illumination;

from the digitized image, determining pixel intensity drop off caused by a combination of a reduction in illumination of image points at the edge of the digitized image and a variation in illumination across the field of view in proportion to the fourth power of the cosine of an angle between a light ray and an optical path; ~~and~~

from the determined pixel intensity drop off, approximating the reduction in illumination of image points at the edge of the digitized image and the variation in illumination across the field of view in proportion to the fourth power of the cosine of an angle between a light ray and an optical path; and

recovering an intrinsic parameter of the camera other than pixel intensity drop off using substantially only the determined pixel intensity drop off.

50. (Currently Amended) A method for providing an estimate for a camera parameter comprising the steps of:

digitizing an image of a blank textureless surface having a uniform illumination;

from the digitized image, determining a pixel intensity drop off caused by a combination of a reduction in illumination of image points at the edge of the digitized image and a variation in illumination across the field of view in proportion to the fourth power of the cosine of an angle between a light ray and an optical path; ~~and~~

from the determined pixel intensity drop off, approximating the reduction in illumination of image points at the edge of the digitized image and the variation in illumination across the field of view in proportion to the fourth power of the cosine of an angle between a light ray and an optical path; and

recovering an intrinsic parameter of the camera other than pixel intensity drop off using substantially only the determined pixel intensity drop off.

51. (Previously Presented) The method of claim 50, wherein the intrinsic parameter is recovered for use by an image based rendering application.